Annosus Root Disease

IDAHO DEPARTMENT OF LANDS

State Forester Forum

Root diseases are by far the most damaging type of native forest disease in northern Idaho. They are also the most difficult to manage. Infected trees suffer reduced growth, mortality, and increased susceptibility to bark beetle attack. At the stand-level root diseases reduce timber volume and stocking, alter the rate and direction of forest succession, and interfere with short- and long-term forest management objectives. Root diseases are caused by fungi that infect and decay tree roots, causing a loss of both root system function and structure. Loss of root function gradually weakens and kills trees. Loss of root structure results in windthrow of live trees and accelerated collapse of dead trees.

The most important root diseases in Idaho are annosus root disease, Armillaria root disease, and laminated root rot. Any combination of these diseases, referred to as "root disease complexes", may be found acting separately in the same stand or even on the same tree. Annosus root disease, caused by the fungus *Heterobasidion annosum*, can be found throughout Idaho. In addition to Armillaria root disease and laminated root rot it is an important consideration in forest management planning in northern Idaho. It may also affect long-term management of ponderosa pine.

Biology

There are two "types" of the fungus *H. annosum*, the spruce (S)-type and the pine (P)-type, also referred to as "biological species" or "intersterility groups". In Europe these have been designated separate species while in North America the difference is less clear and they are still referred to as the S-type and P-type. Conifer species are variously susceptible to the S- and P-types, and disease incidence and severity vary greatly by host and forest type.

In contrast to *Armillaria ostoyae*, cause of Armillaria root disease, and *Phellinus weirii*, cause of laminated root rot, ***annosus root disease spreads commonly via both root-to-root and spore infection***. *Heterobasidion annosum* spore infection occurs on fresh basal wounds and fresh stump surfaces of susceptible species. Infection in pine is usually limited to stump surfaces, while infection in other species occurs via both stump surface and basal wound infection.

On stump surfaces the fungus can colonize the woody tissue and grow down into the roots, but not all surface infections reach the roots since many variables affect growth of the fungus. Once in the roots, however, it can infect adjacent, mature leave-trees or regeneration at root contacts and grafts via growth of ectotrophic mycelia on root surfaces; the fungus does not grow freely through the soil. As with *A. ostoyae* and *P. weirii* this fungus can survive for several decades in large roots and stumps (Figure 1).

Figure 1: Annosus root disease mortality adjacent to a hollow ponderosa pine stump.

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The long-term presence of inoculum, or fungus-infected woody tissue, makes root disease management very difficult. Roots of non-infected trees contact the infected roots of a living or dead tree, the fungus grows onto the non-infected root, and the disease is perpetuated. The ability to occupy a site for decades and cause disease in consecutive forest generations is why root disease is often referred to as a "disease of the site".

As root disease spreads from tree-to-tree it can form centers of infection where many, but most often not all, of the trees are symptomatic or dead, depending on stand structure and composition. These areas of concentrated damage are referred to as "root disease centers". Numerous annosus root disease centers may be dispersed randomly throughout a stand. In many instances the disease occurs in a "diffuse" distribution affecting scattered individuals of Douglas-fir and true firs.

Annosus root disease centers vary greatly by fungus "type" and forest type. They are found commonly, alone or in conjunction with large Armillaria root disease and laminated root rot centers, in northern Idaho. Infection centers in ponderosa pine, when they occur, are often centered on large pine stumps from previous harvests (Figure 1); damage in this instance tends to be limited to small spots in sapling and pole-sized stands. Annosus root disease in older ponderosa pine - particularly on dry sites - can result in scattered mortality or predisposition to bark beetle attack.

There is no evidence that fire has any significant "cleansing" effect on the underground inoculum of annosus root disease. Stumps producing fruiting bodies of *H. annosum*, particularly if well-decayed and dry, may be consumed by fire, as would well-decayed root channels, but most of the underground inoculum will not be impacted to a large extent.

Unfortunately there is much we do not clearly understand about annosus root disease in Idaho. Among the questions are the impact of P-type *H. annosum* in ponderosa pine; the rate of spore infection of S-type *H. annosum* in fir forests; the role of root-to-root versus spore-spread in fir forests; the size which clones, or genets, of *H. annosum* can attain in different forest types; its dominant role - "root nibbler & butt rotter" versus "tree killer" - in fir forests; and its general distribution in fir forests compared to other root disease pathogens.

Hosts

P-type Heterobasidion annosum

Highly susceptible:	Ponderosa pine and western juniper
Moderately susceptible:	Western white pine, according to historical accounts
Least susceptible:	All other species

S-type *Heterobasidion annosum*

Highly susceptible:	Douglas-fir, grand fir, and subalpine fir
Moderately susceptible:	Western hemlock, western redcedar, and spruce
Least susceptible:	Western larch and pines

Spores of either "type" of *H. annosum* can infect the stump surface of any susceptible conifer. However, damage to surrounding trees occurs only when the species of stump is the host for that specific "type" of *H. annosum*. For example, P-type can cause damage when it infects a ponderosa pine stump with adjacent ponderosa pine. The P-type can also infect a Douglas-fir stump but would not cause damage to adjacent trees of any species.

Recognizing Root Disease in a Stand

Stand-level "signatures" can aid in identifying the presence of root disease. Root disease centers, or areas of concentrated mortality, are the most

obvious. Variously-aged snags and trees with symptomatic crowns will be dispersed in and around such centers or diffusely throughout a stand. Death of susceptible species causes gaps in the overstory canopy which promote conifer regeneration - most often of mid- or late-successional, disease-susceptible species - or ingrowth of brush.

Bark beetles and root disease have a very close association; the reduction in tree vigor and changes in tree physiology caused by root disease can make trees more attractive to bark beetles. Attacks by the fir engraver beetle have been correlated to presence of annosus root disease, except when the beetles reach outbreak status, such as during periods of extended drought. Attacks by western balsam bark beetle on subalpine fir are also correlated with annosus infection. If you diagnose bark beetle mortality in a stand be aware root disease may be present as well. However, since bark beetles kill living trees, evidence of root disease infection may be subtle or undetectable at that point.

Identifying Annosus Root Disease

Descriptions and images of root disease-symptomatic trees can be found in "A Field Guide to Diseases & Insect Pests of Northern and Central Rocky Mountain Conifers". Foresters and landowners should always have this guide on hand when diagnosing forest insect and disease problems.

Root diseases cause gradual loss of root function and structure, an effect reflected in the symptoms which develop in infected trees (Figures 2 & 3). Symptoms of annosus root disease include:

- reduced terminal and lateral growth over a span of several to many years;
- thinning of the crown, often proceeding from the bottom up and inside out;
- off-color or chlorotic (yellowing) foliage; and
- a flush of small cones, referred to as "stress cones", which can persist after the tree dies.

Key point: A general rule-of-thumb is only about half of all root disease-infected trees can be detected by above-ground symptoms at any one time.

Figure 2. Annosus root disease symptoms in mature ponderosa pine.

The size of an infected tree will affect expression of disease symptoms. Larger trees, with more expansive root systems, will develop symptoms more gradually than a sapling or seedling, which may succumb relatively quickly and develop few if any crown symptoms. Large trees may not show symptoms for years after infection until much of their root system has been compromised. Any susceptible tree within 30 feet of an infected tree should be assumed infected. Incipient, or early, decay caused by annosus root disease can be seen

on stump surfaces or within roots of live trees as yellow-brown to red stain, depending on the host (Figure 4).

Figure 3. Typical root disease crown symptoms in Douglas-fir.

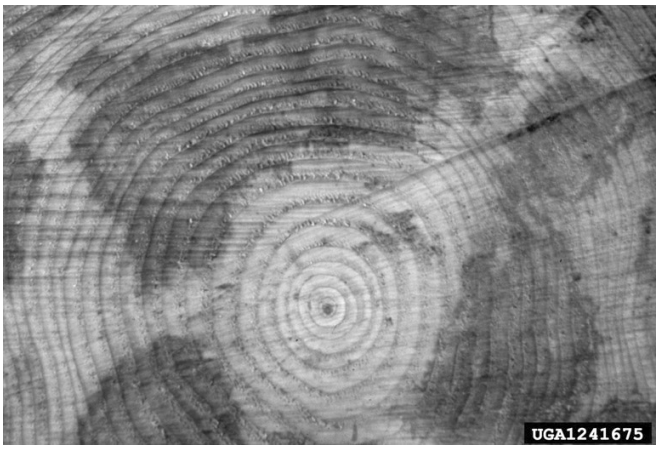

Figure 4. Stain on stump caused by incipient decay.

Advanced decay is generally a white, stringy or spongy mass, often containing small black flecks that run parallel to the grain (Figure 5).

Figure 5. Advanced decay caused by *H. annosum*.

Decayed wood of subalpine or grand fir will tend to separate along the annual rings and have small pits on one side of the delaminations.

Positive identification of annosus root disease can be made by locating fruiting bodies, or conks, of the fungus. Conks of the S-type are typically formed inside hollow stumps of host species, within decayed wood of stumps, or on the underside of roots of windthrown trees; those of the P-type are commonly found in stumps or in the duff layer at the root collar of infected trees. Conks are perennial, woody to leathery, light-gray to dark-brown on top with a creamy-white, small-pored underside (Figure 6).

Figure 6. Fruiting bodies, or conks, of S-type *H. annosum*.

They are often shelf-like and vary in size from very small "button-conks" to fairly large.

Management

Root disease management should be site-specific and based on stand management objectives, the root disease or disease complex present, estimates of root disease severity, stand structure and composition, and stand history. Management of annosus root disease varies by forest type and location so the following recommendations should be viewed as guidelines.

Ponderosa pine forests:

The impact of annosus root disease in ponderosa pine forests in Idaho is not clear. The fungus can be found in decayed stumps but mortality of adjacent, mature trees - as observed in other areas of the West - is not frequently observed. The fungus might be infecting trees adjacent to infected stumps but acting more as a "root nibbler" instead of a "tree killer". Even then it could reduce growth and increase susceptibility to bark beetles.

If a landowner decides to manage for annosus root disease in ponderosa pine the focus should be on preventing disease, a goal which can be achieved by treating stump surfaces with a borax formulation immediately after cutting. Spores of *H. annosum* can still land on the stump but they do not succeed in causing infection. Powdered formulations such as Sporax® are registered for this use and can be applied from a shaker-can across the stump surface (Figure 7).

Figure 7. Pine stump treated with borax to prevent spore infection.

Stumps should be treated with a light coating within 48 hours after cutting, but it is probably most efficient to apply borax at the time trees are felled.

> *Key point*: Stump treatments keep the fungus from infecting stumps and causing disease. It does not have any effect on fungus ***already present*** in stumps and roots.

Only stumps 14" and greater in diameter are recommended for treatment due to the greater likelihood of root contact between roots of large stumps and surrounding leave-trees, and since smaller stumps and roots decay faster.

If annosus root disease is already present and causing damage then management must revert to selection of less susceptible species. However, ponderosa pine is often most-suited to sites where it dominates.

Use of stump treatments to guard against infection by the "P-type" of *H. annosum* represents a cheap, relatively easy-to-apply "insurance policy" to help ensure long-term site productivity. Private landowners managing small parcels of ponderosa pine might well consider it. Managers of large public or private forests need to balance potential risks against added cost.

Homeowners and recreation area managers ***should use stump treatments*** any time they remove ponderosa pine due to the high value of residual trees, particularly large ponderosa pine, on these sites.

Douglas-fir and true fir forests:
Root disease management should be site-specific and based on stand management objectives, the root disease or disease complex present, estimates of root disease severity, stand structure and composition, and stand history. Management of root disease is not a "one-size-fits-all" proposition so the following should be viewed as guidelines.

Determine objectives: Formulate management objectives for the stand in question. A timber production objective requires very careful consideration of root disease; other objectives may not.

Estimate "root disease severity": An estimate of root disease severity (Table 1) provides a "snapshot" of current root disease impact and mortality rates, as well as the best estimate of future mortality and the trajectory of stand structure and composition. Root disease severity, and thus appropriate management, can vary throughout a stand.

Regeneration harvest: If root disease is severe and few disease-resistant species are available to select as leave-trees, and your objective is timber production, then the best option from a disease management standpoint is to clearcut the stand and start over.

> *Key Point*: Salvaging dead and dying trees on root disease centers will capture such volume before it becomes unmerchantable, but due to the biology of the fungi that cause root disease, salvage **does not** reduce mortality or halt spread of root disease.

Stand establishment: Trees planted on sites with root disease need to be disease-tolerant. Western larch or pine species would be good choices, depending on the site; Douglas-fir, subalpine fir, and grand fir will be severely damaged. Ensure quality-control during planting since "J-rooted" seedlings of any species are readily damaged by root disease. Soil compaction appears to increase root disease damage so plan skid trails carefully and minimize the area occupied by landings.

> *Key Point*: Managing for disease-tolerant species is usually the most effective and cost-efficient means of overcoming root disease.

Precommercial stands: Many stands composed of disease-susceptible species have been established, either by planting or natural regeneration, in the presence of moderate to severe root disease. Such stands often show few symptoms of disease till age 10-15 after roots of the growing trees have contacted inoculum from the previous stand and numerous pockets of annosus root disease begin to appear. In such instances, whether precommerical thinning has been done or not, the best option may be to destroy the current stand and start over with disease-tolerant species; a better yield will almost certainly result.

If a young stand has extensive root disease mortality but includes well-distributed, disease-tolerant species then delay thinning at least several years to allow the root disease time to "select" which trees will survive before you invest in thinning. If thinning is eventually done leave a higher-than-normal stocking of disease-tolerant trees in anticipation that more will die as the stand matures. In many instances, however, root disease will reduce stocking to where only "clumps" may need thinning.

Young stands with a "light" root disease severity rating can be thinned without delay, but emphasize selection of disease-tolerant species over maintaining uniform spacing.

> *Key point*: Precommercial thinning that favors and promotes disease-tolerant species will aid root disease management and protect your investment in regeneration and thinning.

Commercial stands: Thinning is not recommended in stands impacted by annosus root disease if Douglas-fir or grand fir will compose more than 30% of leave-trees. Many susceptible trees in such a stand will already be infected, even if not displaying symptoms, and die within a few years of thinning.

A landowner may be sorely tempted to thin a root-diseased stand, leaving the best-looking Douglas-fir and grand fir, with the expectation these trees will experience "increased vigor" and thus resist root disease. The evidence is not clear at this time whether thinning accelerates damage in such a situation, but it is clear that ***mortality rates will not decrease in disease-susceptible species***.

Management of stands impacted by annosus root disease should emphasize promotion and maintenance of seral species. Silvicultural approaches that achieve this objective are

recommended even for stands with a light root disease severity rating. Managing for disease-susceptible species, and harvesting the disease tolerant species, will result in ever-increasing amounts of disease inoculum and only serve to worsen root disease severity and reduce management options for the next rotation.

> *Key point*: Long-term root disease management should take a "***do no harm***" approach by maintaining and promoting mature seral species and their natural regeneration, planting with disease-tolerant species, and taking no actions which will increase long-term inoculum levels.

Inoculum removal: Using heavy machinery to remove stumps and large roots from the ground in root-diseased stands can reduce short-term damage in the subsequent stand due to reduction in inoculum, but long-term results are mixed. Inoculum removal requires ***very careful*** consideration based on slope, soil moisture and type, and site productivity. While it is not considered economically practical in commercial forests of Idaho, private landowners with small parcels of land impacted by root disease might consider this option under the right circumstances.

Fertilization: At this time there is no evidence that fertilizing reduces either spread or severity of annosus root disease.

Table 1. Root disease severity.

Root Disease Severity	Range of Conditions
Light	Includes stands with no evidence of root disease, stands with no mortality but numerous trees displaying symptoms, and stands with *up to 20% canopy reduction due to root disease mortality*.
Moderate	Includes stands with *20-75% canopy reduction due to root disease mortality*. At the lower end of this range there will also be many trees with root disease symptoms, while at the upper end much of the remaining overstory canopy consists of disease-tolerant species. Moderate severity stands are changing quickly; mortality rates are high.
Severe	Includes stands with *at least 75% canopy reduction due to root disease mortality*. These stands are usually composed of only the most susceptible species. At the lower end of this range only a few susceptible overstory trees remain although there may be densely stocked, susceptible regeneration; at the upper end no susceptible species remain in the overstory. Mortality rates in this category will begin to slow because most susceptible species are already dead.

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